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(54) **NON-INVASIVE MEASUREMENT OF ARTERIAL INPUT FUNCTION FOR POSITRON EMISSION TOMOGRAPHY IMAGING**

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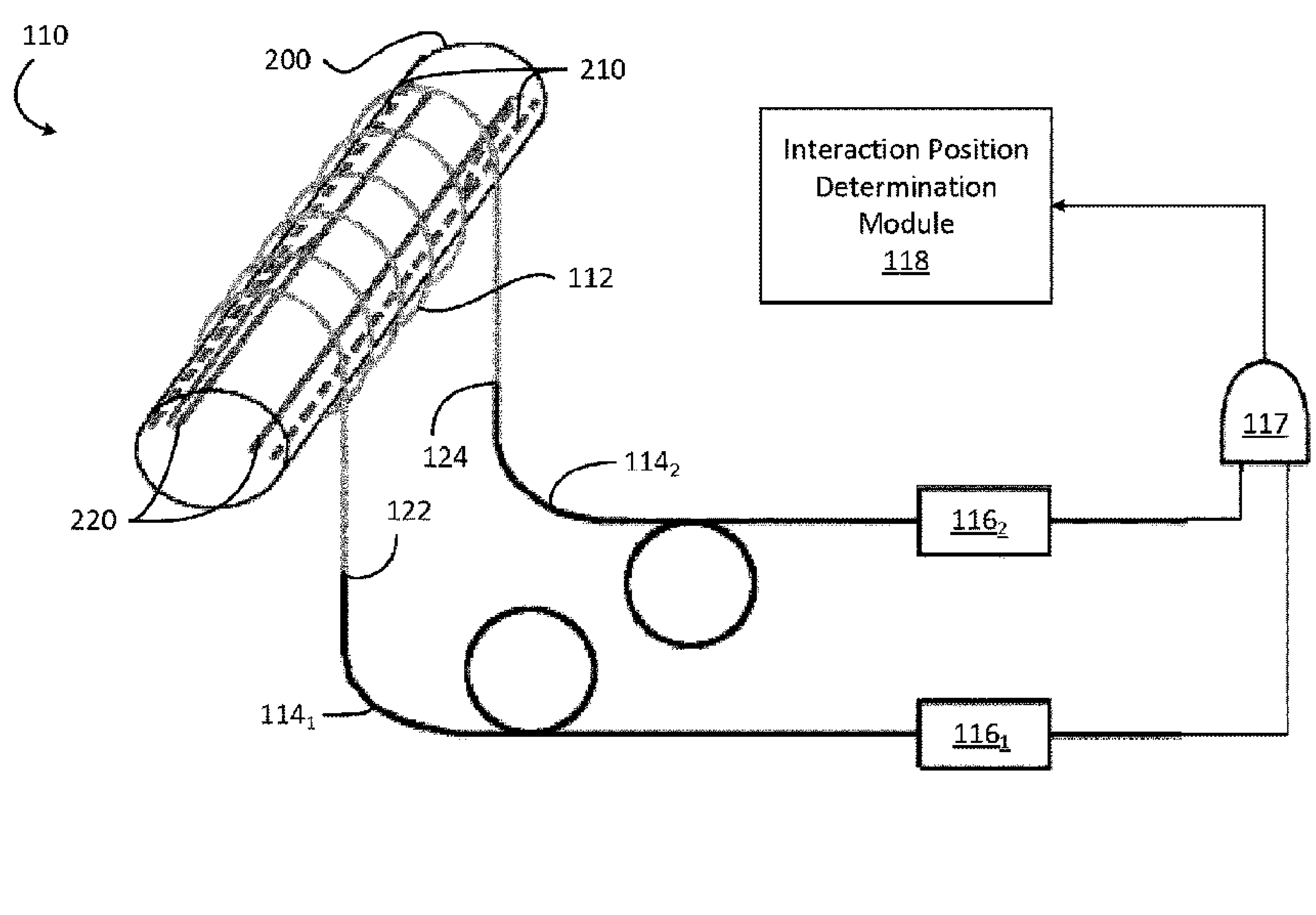
(57) **ABSTRACT**

Methods and systems for establishing a kinetic model input function (IF) in positron emission tomography and single-photon emission computed tomography are provided. A position of interaction along a scintillating fiber coil is determined by: detecting a first plurality and second plurality of photons at first and second ends of the scintillating fiber coil; associating the first plurality of photons and the second plurality of photons with the interaction event based
(Continued)



on a timing parameter; and determining a position of interaction for the interaction event based on a comparison between a first parameter of the first plurality of photons and a second parameter of the photons in the second plurality of photons.

19 Claims, 9 Drawing Sheets

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G01T 1/29	(2006.01)
G01T 1/172	(2006.01)
G01T 1/20	(2006.01)
G21K 1/02	(2006.01)
G01T 1/16	(2006.01)

(52) **U.S. Cl.**
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(58) **Field of Classification Search**
CPC G01T 1/201; G01T 1/2985; G21K 1/02; G01R 33/481
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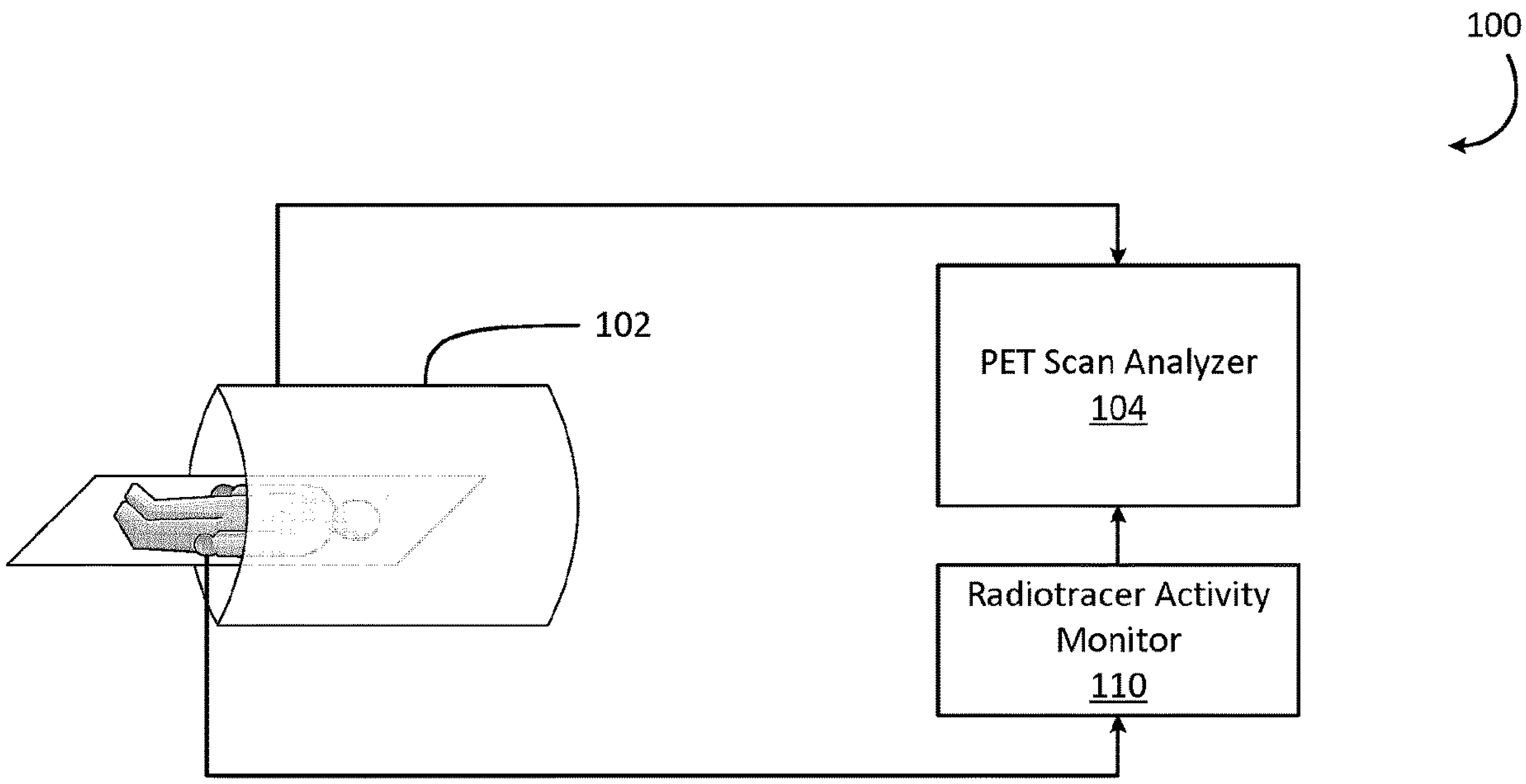

100
102
PET Scan Analyzer
104
Radiotracer Activity
Monitor
110

FIGURE 1

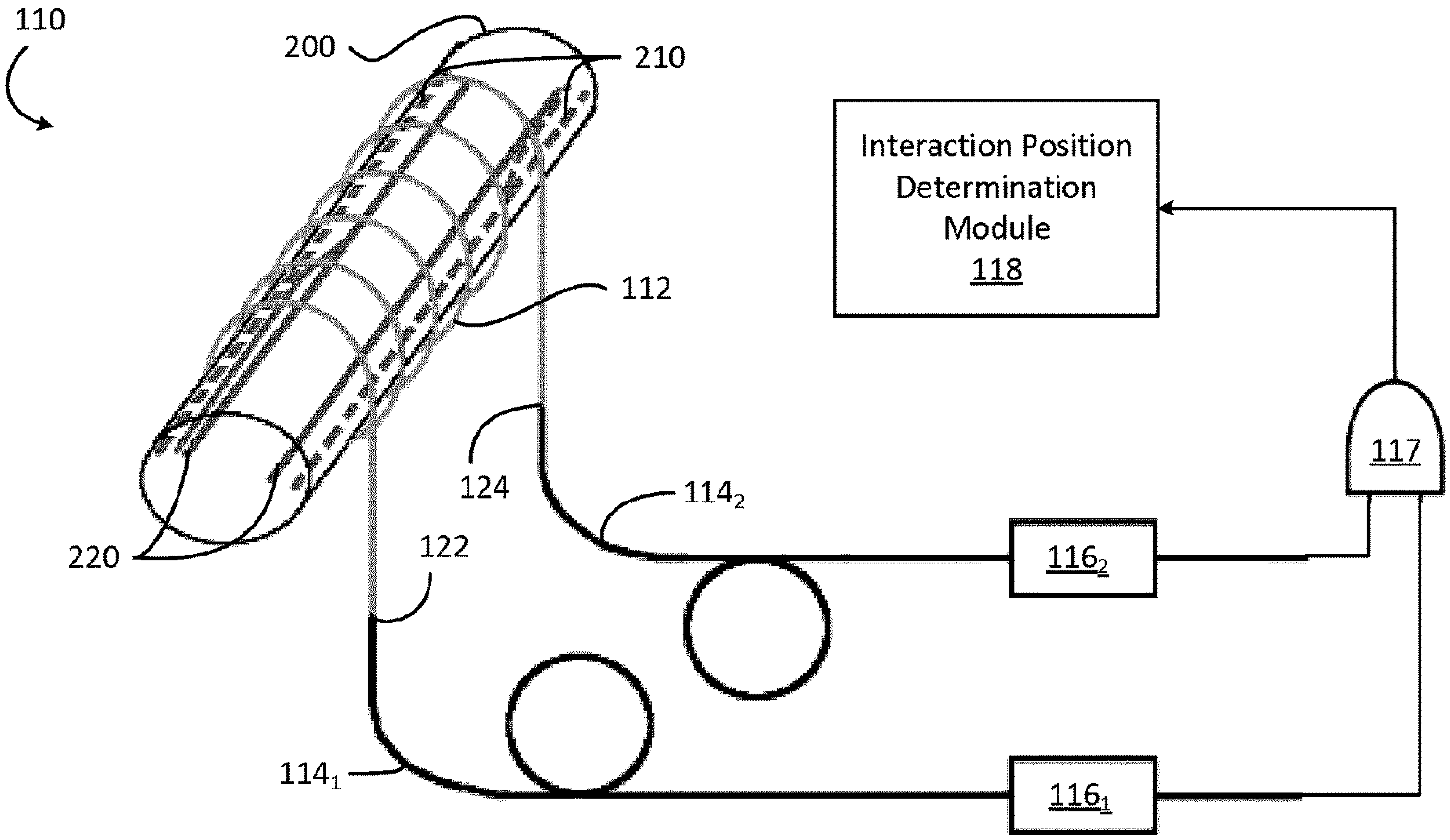

110
200
210
112
124
114_2
122
220
114_1
Interaction Position Determination Module 118
117
116_2
116_1

FIGURE 2

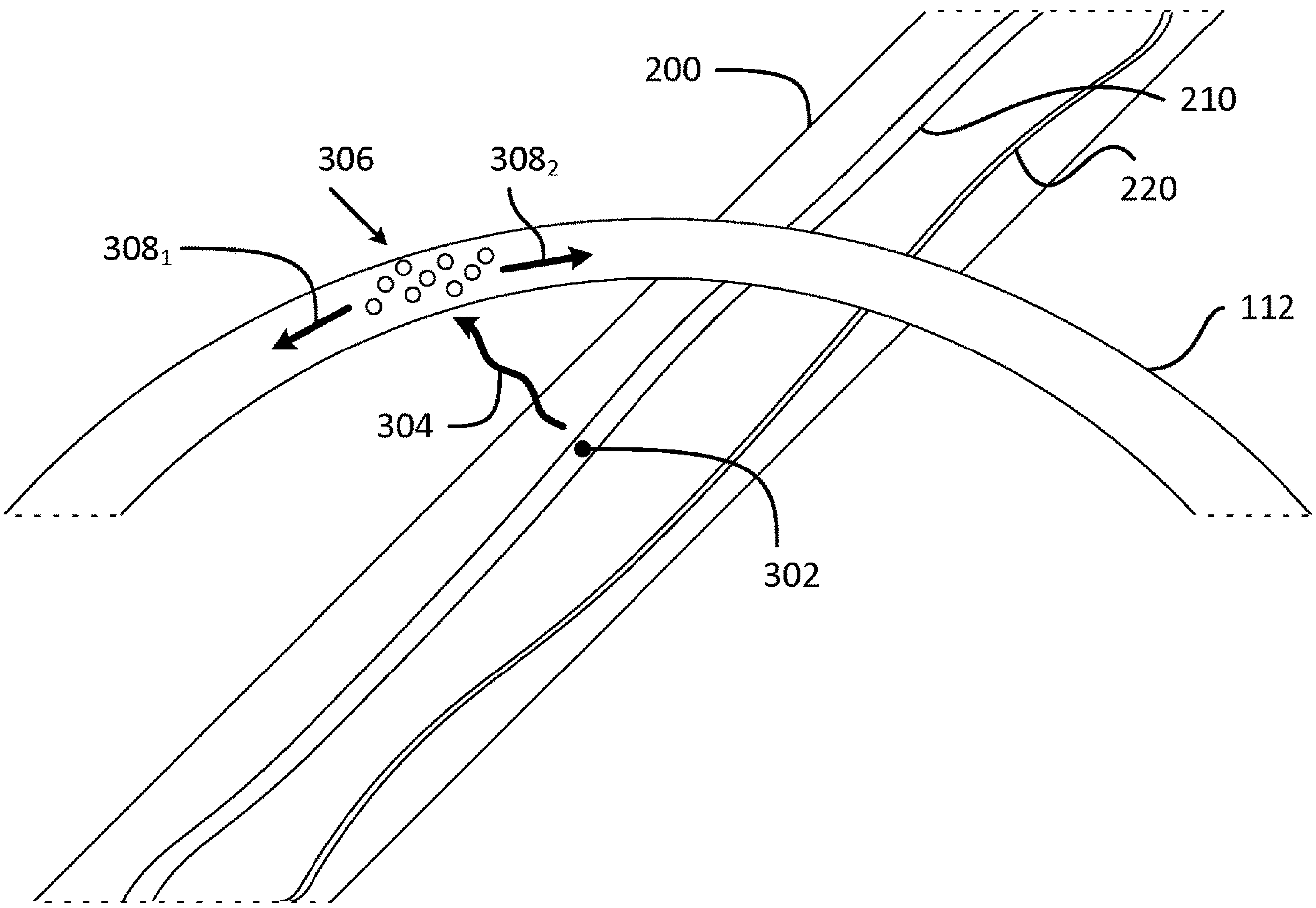


FIGURE 3A

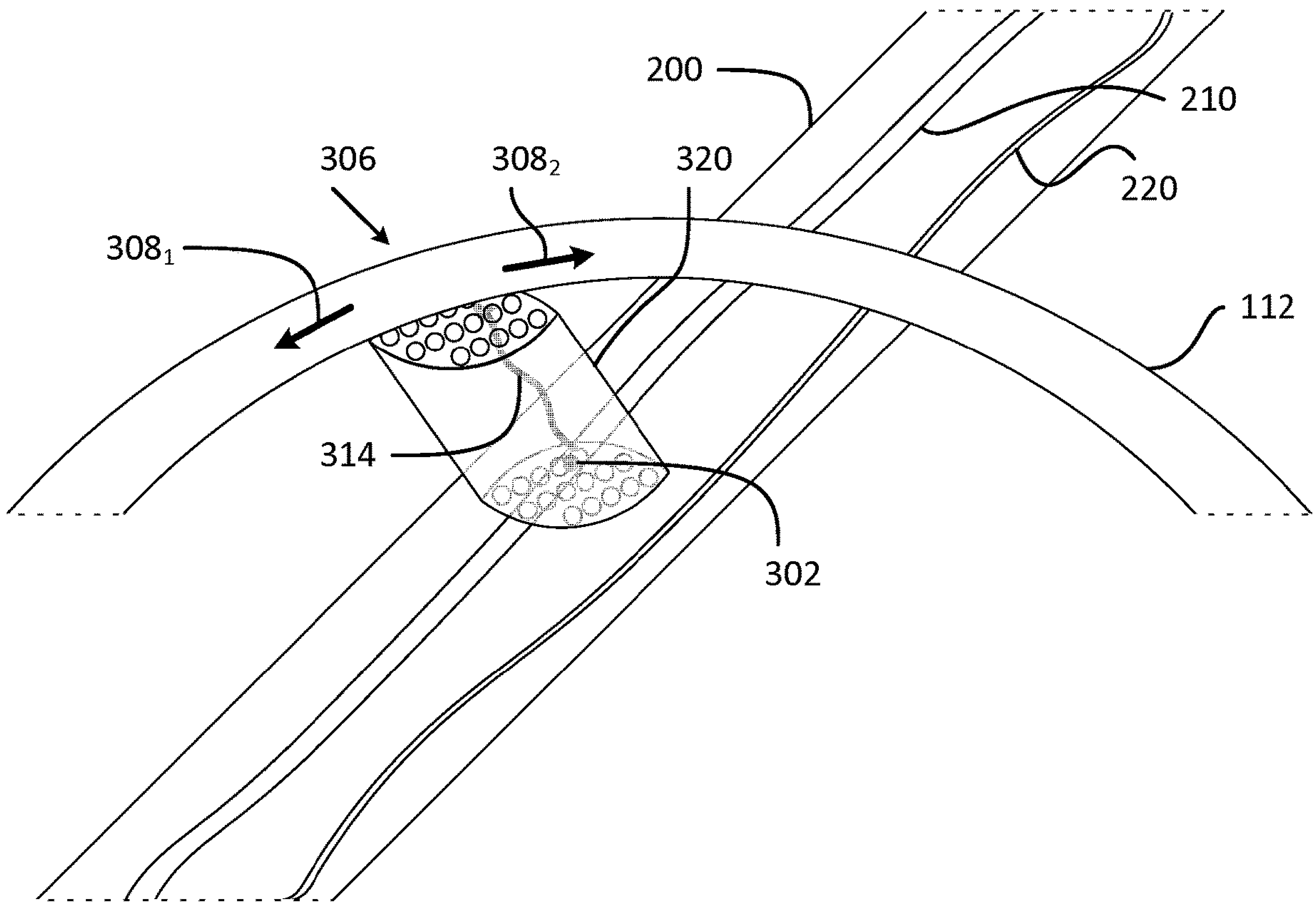
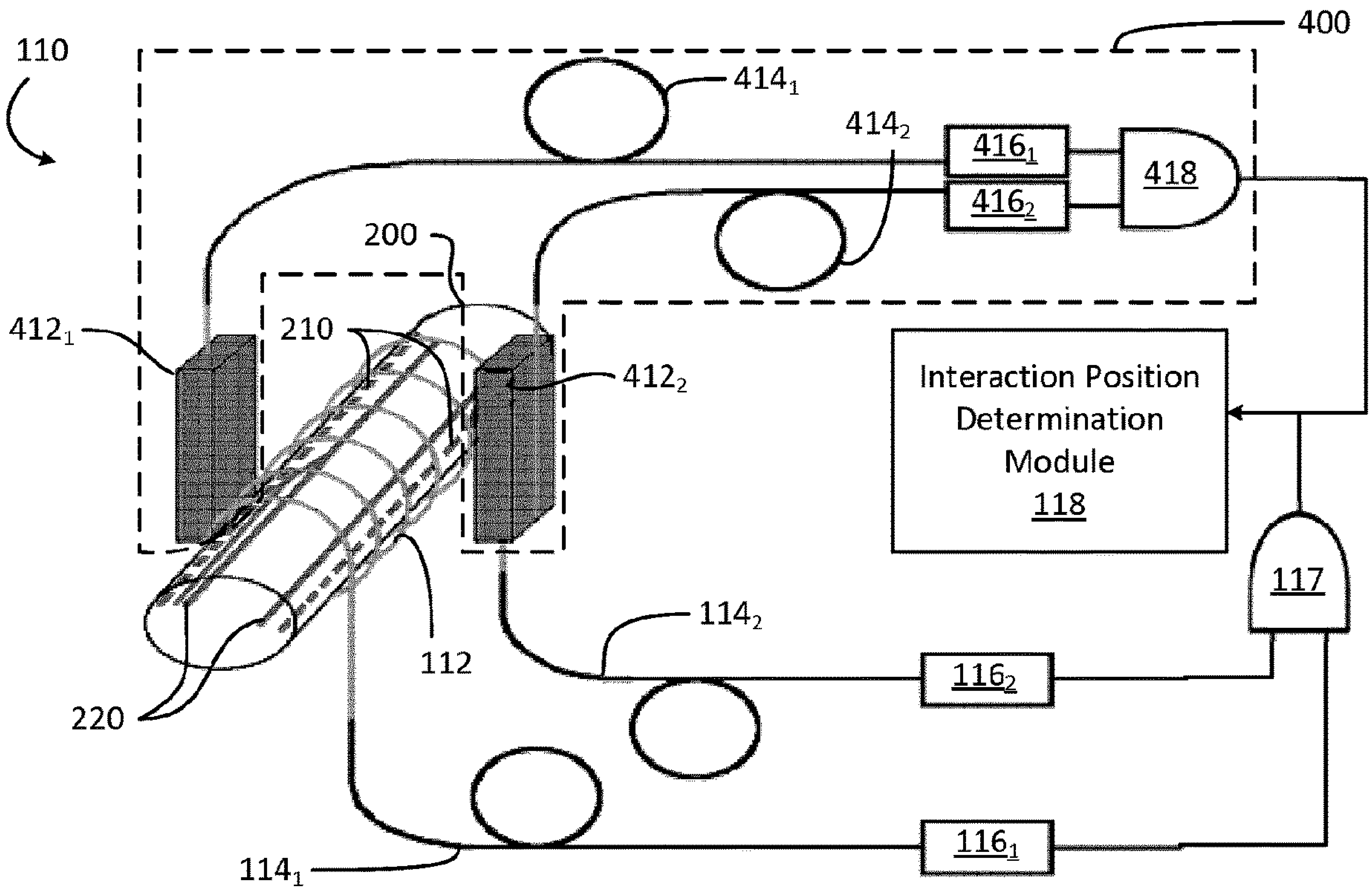
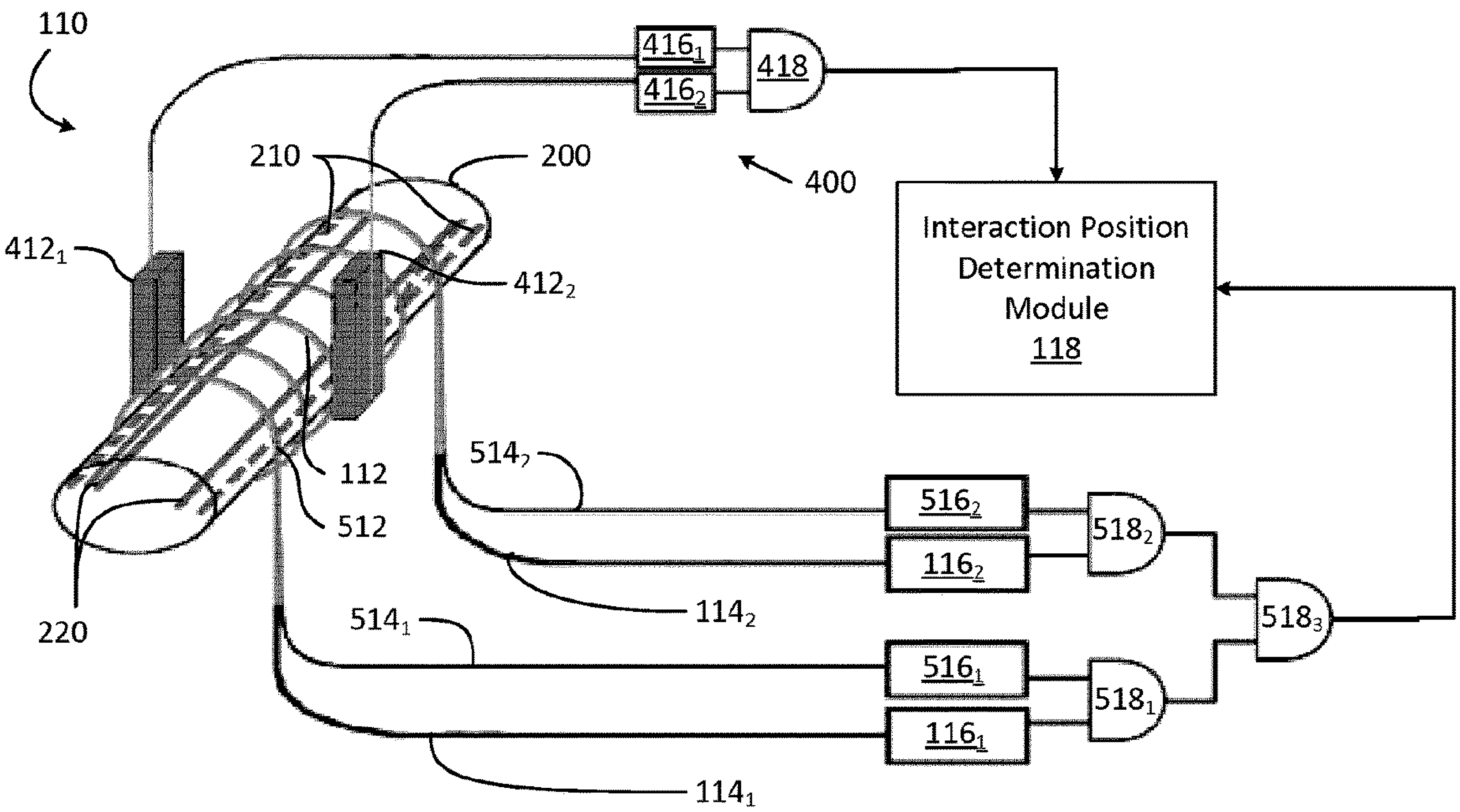


FIGURE 3B



110
400
414_1
414_2
416_1
416_2
418
200
412_1
210
412_2
Interaction Position Determination Module 118
117
114_2
116_2
112
220
116_1
114_1

FIGURE 4



110
416_1
416_2
418
210
200
400
412_1
412_2
Interaction Position Determination Module 118
112
512
514_2
516_2
116_2
518_2
518_3
220
114_2
514_1
516_1
518_1
116_1
114_1

FIGURE 5

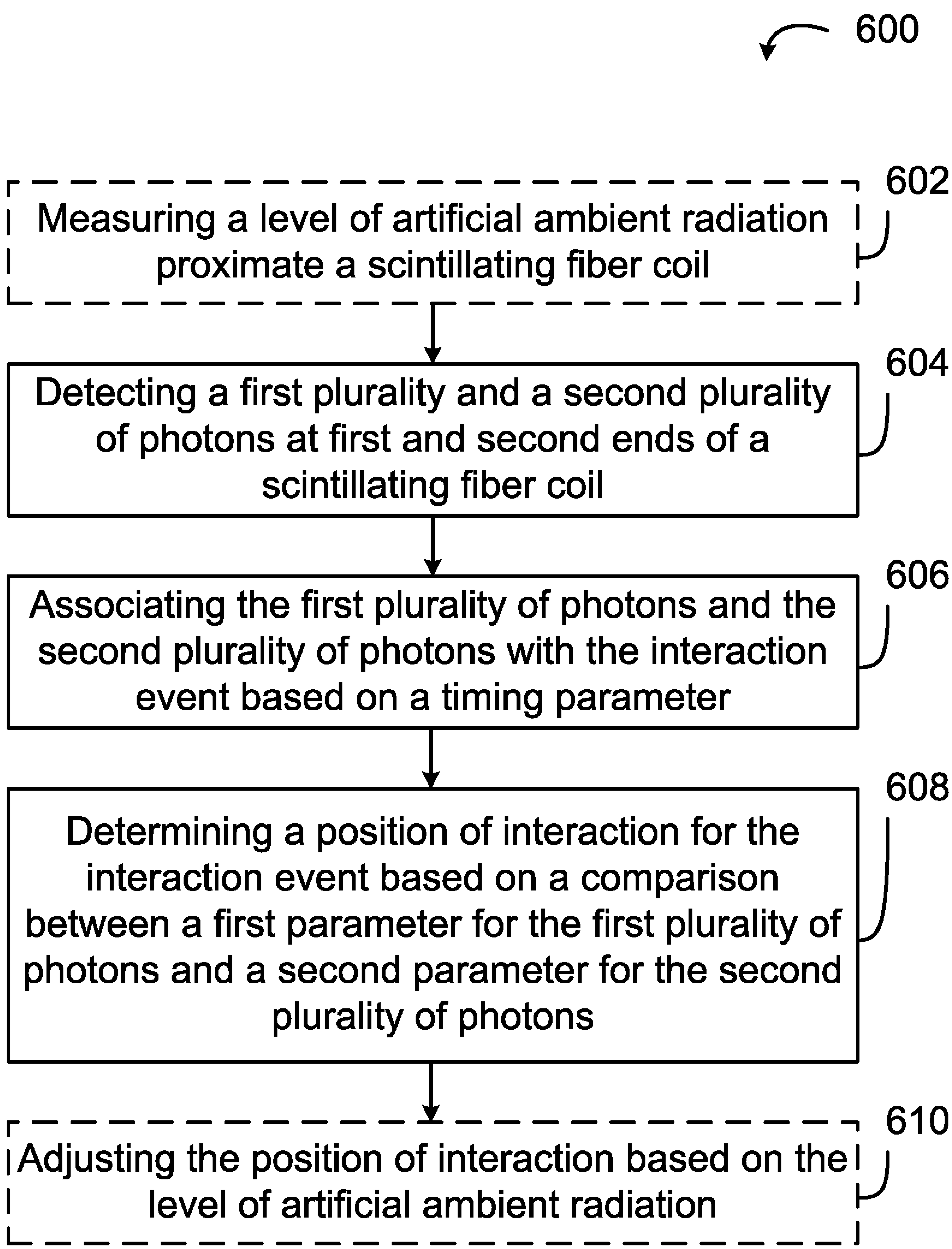

600
602
Measuring a level of artificial ambient radiation proximate a scintillating fiber coil
604
Detecting a first plurality and a second plurality of photons at first and second ends of a scintillating fiber coil
606
Associating the first plurality of photons and the second plurality of photons with the interaction event based on a timing parameter
608
Determining a position of interaction for the interaction event based on a comparison between a first parameter for the first plurality of photons and a second parameter for the second plurality of photons
610
Adjusting the position of interaction based on the level of artificial ambient radiation

FIGURE 6

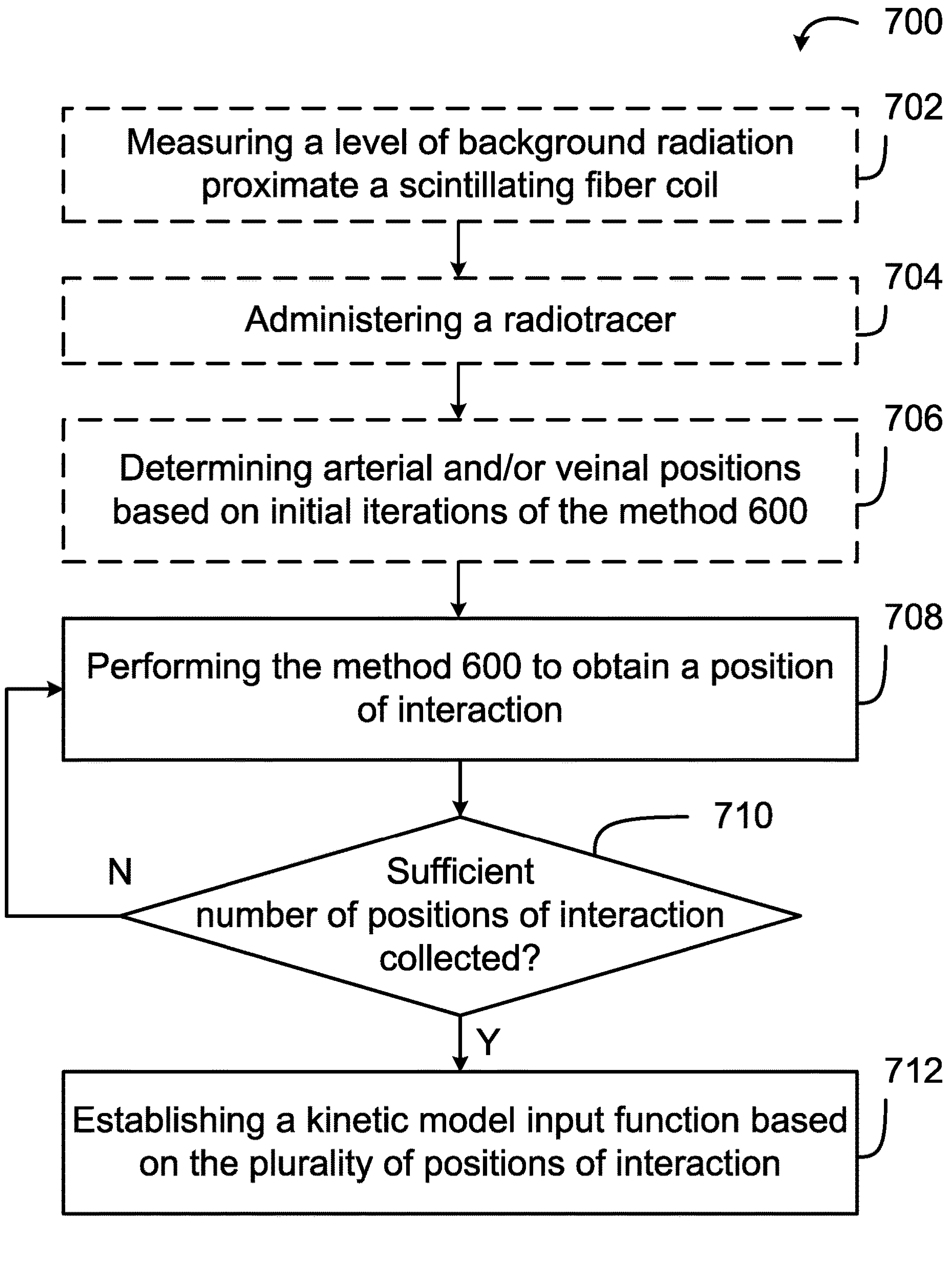

700
702
Measuring a level of background radiation proximate a scintillating fiber coil
704
Administering a radiotracer
706
Determining arterial and/or veinal positions based on initial iterations of the method 600
708
Performing the method 600 to obtain a position of interaction
710
Sufficient number of positions of interaction collected?
N
Y
712
Establishing a kinetic model input function based on the plurality of positions of interaction

FIGURE 7

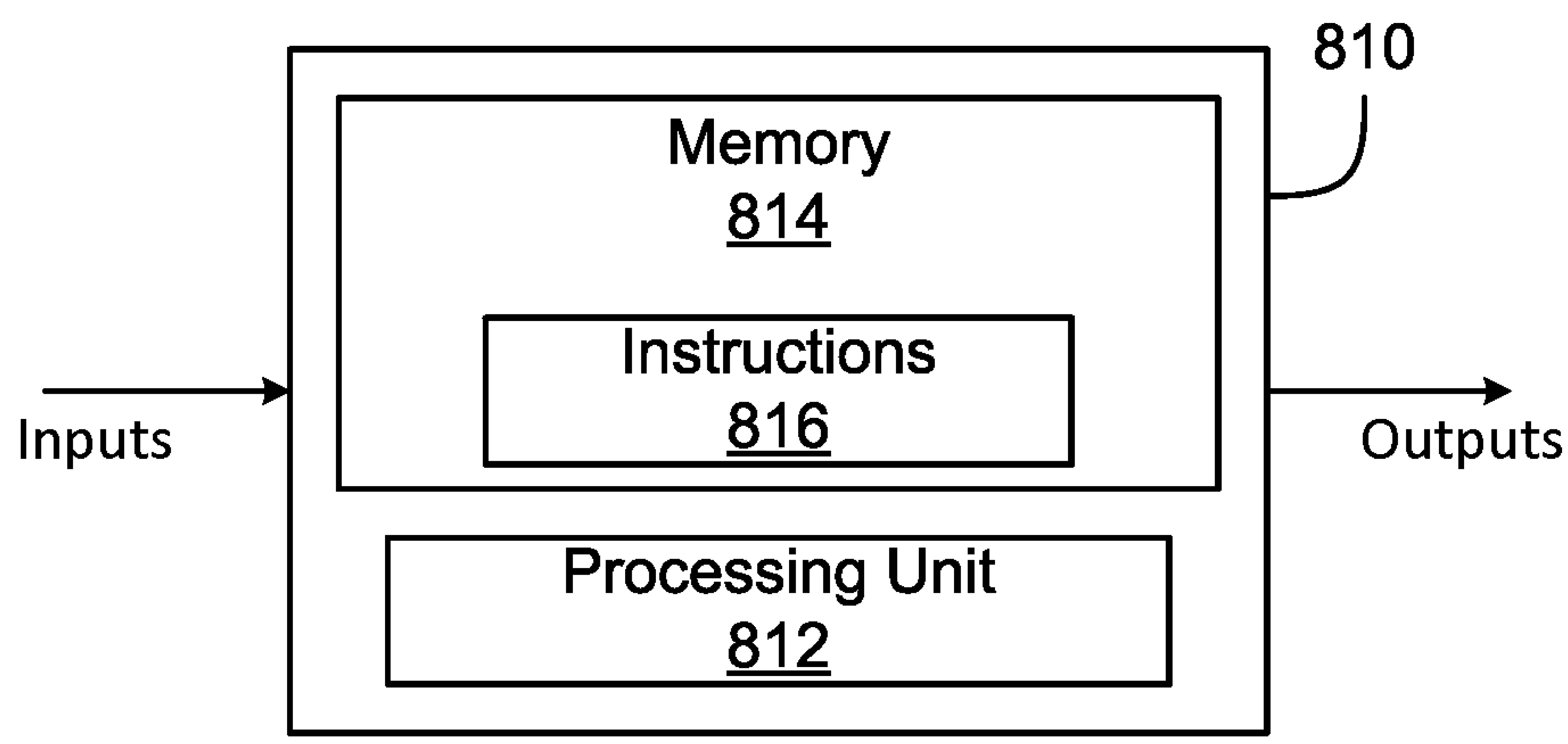

810
Memory
814
Instructions
816
Inputs
Outputs
Processing Unit
812

FIGURE 8

NON-INVASIVE MEASUREMENT OF ARTERIAL INPUT FUNCTION FOR POSITRON EMISSION TOMOGRAPHY IMAGING

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims the benefit of U.S. Provisional Patent Application No. 62/531,157 filed on May 31, 2017, the contents of which are hereby incorporated by reference.

TECHNICAL FIELD

The present disclosure relates generally to imaging techniques, and more particularly to the acquisition of an input function (IF) for use with positron emission tomography (PET) imaging, single-photon emission computed tomography (SPECT), and PET-magnetic resonance imaging (PET-MRI).

BACKGROUND OF THE ART

PET, SPECT and PET-MRI are functional imaging techniques using radioactive tracers to obtain anatomical and physiological information in a target volume. The PET technique is based on detection of positron-electron annihilation events and the SPECT technique is based on detection of gamma emission events. When performing a PET scan, a positron (β+) emitting radioactive tracer (also known as a radiotracer) is administered to the patient before or during the scan and the interaction of that molecule with the body's physiological processes can be monitored. A SPECT scan monitors physiological processes similarly to the PET scan, however, the SPECT scan uses a radiotracer that emits photons via gamma events. PET-MRI is a hybrid imaging technology that incorporates magnetic resonance imaging (MRI), soft tissue morphological imaging and PET functional imaging.

Images acquired with PET, SPECT, and PET-MRI are composite of various superimposed signals where only one is of interest. The desired signal may describe a tracer bound to a particular receptor or the amount of tracer trapped at the site of metabolism. In order to isolate the desired component of the signal, mathematical kinetic models are used. These models relate the dynamics of the tracer molecule and all its possible states (compartments) to the resultant PET/SPECT/PET-MRI image.

Mathematical kinetic models require an IF. The concentration of the unchanged (non-metabolized) compound in arterial plasma as a function of time is one such IF and is often referred to as a plasma time-activity curve (PTAC). The traditional manner to obtain the IF is invasive, i.e. arterial blood can be withdrawn by manual or automated blood sampling. There are many issues that accompany this technique, including discomfort to the patient, increased risk of transferring a blood-borne disease, and the need for additional personnel and equipment in withdrawing and assaying the plasma samples.

Therefore, there is a need for a non-invasive technique to acquire the IF. While some non-invasive techniques have been proposed, they have issues with background rejection and spatial resolution. Improvement is desired.

SUMMARY

In accordance with a broad aspect, there is provided a method for determining a position of interaction along a scintillating fiber coil, comprising: detecting a first plurality and second plurality of photons at first and second ends of the scintillating fiber coil, respectively, the first and second pluralities of photons produced by an interaction event between a radiotracer and the scintillating fiber coil; associating the first plurality of photons and the second plurality of photons with the interaction event based on a timing parameter; and determining a position of interaction for the interaction event based on a comparison between a first parameter of the first plurality of photons and a second parameter of the second plurality of photons.

In accordance with another broad aspect, there is provided a method for establishing a kinetic model input function in one of positron emission tomography and single-photon emission computed tomography, comprising: performing the method of determining a position of interaction along a scintillating fiber coil above multiple times for a plurality of interaction events to obtain a plurality of positions of interaction; and establishing the kinetic model input function based on the plurality of positions of interaction.

In some embodiments, the method further comprises measuring a level of background radiation proximate the scintillating fiber coil, wherein determining a position of interaction comprises adjusting the first and second levels of attenuation based on the level of background radiation.

In some embodiments, detecting the first plurality and second plurality of photons produced by the scintillating fiber coil comprises receiving the first and second pluralities of photons via an optical fiber.

In some embodiments, an attenuation coefficient of the optical fiber is lower than an attenuation coefficient of the scintillating fiber coil.

In some embodiments, detecting the first plurality and second plurality of photons produced by the scintillating fiber coil comprises determining, via a coincidence detector, that the first plurality of photons and the second plurality of photons are produced by the interaction event based on a time of receipt of the first plurality of photons and of the second plurality of photons.

In some embodiments, the first and second parameters are first and second attenuation levels, respectively.

In some embodiments, the method further comprises positioning the scintillating fiber coil to substantially cover a portion of a body.

In some embodiments, the portion of the body is a wrist.

In some embodiments, the method further comprises administering the radiotracer.

In accordance with a further broad aspect, there is provided a device for establishing a kinetic model IF in positron emission tomography and single-photon emission computed tomography, comprising: a scintillating fiber coil arranged for substantially covering a portion of a body, the scintillating fiber coil having a first end and a second end; at least one photon detector optically connected to the first and second ends of the scintillating fiber coil; and a processing device communicatively coupled to the at least one photon detector and configured for: for each of a plurality of interaction events between the scintillating fiber coil and a radiotracer: detecting first and second pluralities of photons at first and second ends of the scintillating fiber coil, respectively, the first and second pluralities of photons produced by the interaction event; associating the first plurality of photons and the second plurality of photons with the interaction event based on a timing parameter; and determining a position of interaction for the interaction event based on a comparison between a first parameter of the first plurality of photons and a second parameter of the second plurality of photons; and establishing a kinetic model input function based on the positions of interaction.

In some embodiments, the device further comprises an ambient radiation monitor communicatively coupled to the processing device, wherein the processing device is further configured for obtaining a measurement of a level of background radiation proximate the scintillating fiber coil from the ambient radiation monitor, and wherein determining a position of interaction comprises adjusting the first and second levels of attenuation based on the level of background radiation.

In some embodiments, the level of background radiation comprises radiation produced by the body.

In some embodiments, the device further comprises an optical fiber, wherein the at least one photon detector is optically connected to the first and second ends of the scintillating fiber coil via the optical fiber.

In some embodiments, an attenuation coefficient of the optical fiber is lower than an attenuation coefficient of the scintillating fiber coil.

In some embodiments, the device further comprises a coincidence detector, wherein the processing device is configured for operating the coincidence detector to detect the first plurality and second plurality of photons produced by the scintillating fiber coil to determine that first plurality of photons and the second plurality of photons are produced by the interaction event based on a time of receipt of the first plurality of photons and of the second plurality of photons.

In some embodiments, the first and second parameters are first and second attenuation levels, respectively.

In some embodiments, the portion of the body is a wrist.

In some embodiments, the device further comprises a subsequent scintillating fiber coil optically connected to the at least one photon detector, wherein the processing device is further configured for performing the steps of detecting, associating, and determining for third and fourth pluralities of photons for a subsequent plurality of interaction events between the subsequent scintillating fiber coil and the radiotracer.

In some embodiments, wherein the subsequent scintillating fiber coil is arranged for substantially covering a subsequent portion of the body at least in part different from the portion of the body.

BRIEF DESCRIPTION OF THE DRAWINGS

Further features and advantages of the present invention will become apparent from the following detailed description, taken in combination with the appended drawings, in which:

FIG. **1** is a diagram illustrating an example PET scan system or a SPECT scan system or PET-MRI scan system.

FIG. **2** is a block diagram illustrating a first embodiment of a radiotracer activity monitor.

FIG. **3**A is a block diagram illustrating an example positron-electron disintegration emission.

FIG. **3**B is a block diagram illustrating an example photon emission.

FIG. **4** is a block diagram illustrating a second embodiment of a radiotracer activity monitor.

FIG. **5** is a block diagram illustrating a third embodiment of a radiotracer activity monitor.

FIG. **6** is a flowchart of an example method for determining a position of interaction along a scintillating fiber coil.

FIG. **7** is a flowchart of an example method for establishing a kinetic model IF in PET/SPECT/PET-MRI.

FIG. **8** is a schematic diagram of an embodiment of a computing system for implementing the method of FIGS. **6** and/or **7** in accordance with an embodiment.

It will be noted that throughout the appended drawings, like features are identified by like reference numerals.

DETAILED DESCRIPTION

With reference to FIG. **1**, a scan system **100** is shown. The scan system **100** may be a PET scan system, a SPECT scan system, or a PET-MRI scan system. The scan system **100** includes a scanner **102**, a scan analyzer **104**, and a radiotracer activity monitor **110**. The scanner **102** can be any suitable PET/SPECT/PET-MRI scanner providing PET/SPECT/PET-MRI scan data to the scan analyzer **104**, and the scan analyzer **104** can be any suitable computer or processing system configured for analyzing the PET/SPECT/PET-MRI scan data received from the scanner **102**, including by implementing mathematical kinetic models used to isolate desired components of the signals received from the scanner **102**. The mathematical kinetic models implemented by the scan analyzer **104** require an input function (IF). The IF is supplied to the scan analyzer **104** by the radiotracer activity monitor **110**.

With reference to FIG. **2**, an embodiment of the radiotracer activity monitor **110** is shown. The radiotracer activity monitor **110** includes a scintillating fiber coil **112** having first and second ends, a pair of fiber optic cables $\mathbf{114}_1$, $\mathbf{114}_2$ connected at each end of the scintillating fiber coil **112**, a pair of photon detectors $\mathbf{116}_1$, $\mathbf{116}_2$, each connected to a respective one of the fiber optic cables $\mathbf{114}_1$, $\mathbf{114}_2$, a coincidence detector **117** connected to the photon detectors $\mathbf{116}_1$, $\mathbf{116}_2$, and an interaction position determination module **118**, to which the coincidence detector **117** is connected.

The scintillating fiber coil **112** is an optical fiber or other light-guiding filament having first and second ends **122**, **124** and which is shaped into a plurality of spaced curved patterns, for example circular-shaped loops, S-shaped patterns, zigzag patterns, and the like. The spacing between the curved patterns may be constant or vary along the length of the scintillating fiber coil **112**, and the scintillating fiber coil **112** has any suitable number of curved patterns and of any suitable size. In some embodiments, the bending radius of the scintillating fiber coil is constant to generate a constant light attenuation constant within the scintillating fiber coil. In some embodiments, the configuration of the scintillating fiber coil **112** is substantially fixed, and in other embodiments one or more of the spacing, size, and/or count of the curved patterns is adjustable. In some embodiments, the scintillating fiber coil **112** is mounted around or retained within a rigid structure. For example, a cylindrical shell featuring a spiral or cylindrical bore for receiving the scintillating fiber coil can be provided. The shell can be sized for receiving a body part, and can optionally include an inflatable bladder or similar device for securing the body part within the shell. In some cases, the shell can be produced by 3D printing.

The curved patterns of the scintillating fiber coil **112** are configured for receiving or otherwise having inserted therein a portion **200** of a body, for example of a human patient, an animal patient, or any other suitable patient. In some embodiments, the scintillating fiber coil **112** substantially encircles the portion **200**. In other embodiments, the scintillating fiber coil **112** substantially covers part or all of the portion **200**. The portion **200** may be a wrist, an arm, an ankle, a leg, a neck, a torso, or any other suitable portion.

Running within the portion **200** of the body are at least one artery **210**, illustrated by the dashed lines, and/or at least one vein **220**, illustrated by the unbroken lines. In some embodiments, the scintillating fiber coil **112** is positioned to be proximate or in contact with a surface of the portion **200** of the body, for example proximate or in contact with a skin surface of the portion **200**. In some embodiments, a collimator is placed between the scintillating fiber coil **112** and the skin surface of the portion **200**. In some embodiments, the curved patterns of the scintillating fiber coil **112** are positioned to increase the number of loops around sections of the portion **200** where the one or more arteries **210** and/or veins **220** are closest to the surface of the portion **200**. In other embodiments, the curved patterns of the scintillating fiber coil **112** are distributed substantially evenly along the portion **200**.

With reference to FIGS. **3**A and **3**B, the scintillating fiber coil **112** incorporates a radioluminescent material, that is to say a material comprising a plurality of molecules **306** which emit light when the molecules **306** absorb radiation. This can include alpha radiation, beta radiation, gamma radiation, any suitable combination thereof, or any other suitable kind of radiation. The scintillating fiber coil **112** may be made of any one or more of glass, plastic, crystal, or in some cases may be a tube or other container filled with a liquid material. The radioluminescent material may be embedded within the scintillating fiber coil **112**, for example the scintillating fiber coil **112** includes an organic material, for example BCF-12™ and/or BCF-60™. Alternatively, the radioluminescent material can be obtained in powder form, mixed with an adhesive, and then applied to a surface of the scintillating fiber coil **112**. Examples of radioluminescent materials in powder form include inorganic scintillators Y_2O_3:Eu and Gd_2O_2S:Tb. In some embodiments, a range of diameter of the scintillating fiber coil **112** is less than or equal to 5 mm. In other embodiments, other diameters of the scintillating fiber coil **112** are considered. The scintillating fiber coil **112** may have any suitable cross-section. When a positron or other radioactive particle collides with, or otherwise interacts with, the scintillating fiber coil **112**, the molecules **306** of the scintillating fiber coil **112** produce a plurality of photons.

When a radiotracer is administered to the portion **200** of the body, or to the body generally, radiotracer particles, for example the particle **302**, will flow through the artery **210**. In some embodiments, the radiotracer can be any suitable positron-emitting radiotracer for administering to a body, including isotopes of carbon, nitrogen, oxygen, fluorine, gallium, zirconium, rubidium, and the like. In other embodiments, the radiotracer can be any suitable photon emitting radiotracer for administering to a body, including isotopes of technetium, indium, iodine, and the like. Although the particle **302** is shown as flowing through the artery **210**, it should be understood that the particle **320** can also flow through the vein **220**. In addition, although the following discussion focuses on positron-emitting radiotracers, other types of radiotracers are considered.

With continued reference to FIG. **3**A, in some embodiments the radiotracer particle **302** is a positron-emitting particle. When the radiotracer particle **302**, flowing through the artery **210**, emits a positron **304**, the positron **304** may be directed toward the scintillating fiber coil **112**. During traversal of the scintillating fiber coil **112**, the positron **304** causes the molecules **306** to produce photons, which are emitted isotropically. A first plurality of the photons, illustrated by the arrow $\mathbf{308_1}$, travels along the scintillating fiber coil **112** in a first direction, and a second plurality of the photons, illustrated by the arrow $\mathbf{308_2}$, travels along the scintillating fiber coil **112** in a second direction opposite the first direction. Although the photons produced by the molecules **306** may scatter in multiple directions, the light-guiding properties of the scintillating fiber coil **112** cause at least some of the photons produced by the molecules **306** to form the first and second pluralities of photons $\mathbf{308_1}$, $\mathbf{308_2}$ which travel along the scintillating fiber coil **112** in opposite directions, as illustrated by the arrows.

In some embodiments, the distance between the superficial artery **210** or the vein **220** and the surface of the portion **200** is approximately 2-3 mm. Depending on the radiotracer used, positrons **304** emitted by the radiotracer particles **302** used for PET imaging have a range of travel distances in tissue which composes the portion **200**. For example, positrons emitted from Fluorine-18 have a range of 2.6 mm, and positrons emitted from Gallium-68 have a range of 10.3 mm. In embodiments which use a positron-emitting radiotracer, the scintillating fiber coil **112** is placed in close proximity to the surface of the portion **200**. This may facilitate collisions between the emitted positrons **304** and the radioluminescent molecules **306** in the scintillating fiber coil **112**.

With continued reference to FIG. **3**B, in some other embodiments the radiotracer particle **302** is a photon-emitting particle. In this embodiment, the radiotracer activity monitor **110** includes a microcollimator **320** which is located between the surface of the portion **200** and the scintillating fiber coil **112**. The microcollimator **320** is made of a high-density material which is placed in contact with a surface of the portion **200** and which connects to the scintillating fiber coil **112**. The microcollimator **320** is provided with a plurality of lengthwise holes which traverse the microcollimator **320**, which serve to narrow and/or focus photons from the portion **200** which is incident the microcollimator **320**. When the radiotracer particle **302**, flowing through the artery **210**, emits a photon **314**, the photon **314** is directed within the microcollimator **320** and carried to the scintillating fiber coil **112**. It should be noted that the photons emitted by the radiotracer, including the photon **314** emitted by the radiotracer particle **302**, are emitted isotropically, that is to say substantially uniformly in all directions. The microcollimator **320** is configured to direct a subset of the emitted photons via the holes in the microcollimator **320** to the scintillating fiber coil **112**. The subset of photons is then collected by the scintillating fiber coil **112** and transmitted as the pluralities of photons $\mathbf{308_1}$, $\mathbf{308_2}$ along the scintillating fiber coil **112**.

With continued reference to FIG. **2**, the pluralities of photons $\mathbf{308_1}$, $\mathbf{308_2}$ travel along the scintillating fiber coil **112** toward the ends **122**, **124** of the scintillating fiber coil **112**. Connected at the first end **122** of the scintillating fiber coil **112** is the photon detector $\mathbf{116_1}$, and connected at the second end **124** of the scintillating fiber coil **112** is the photon detector $\mathbf{116_2}$. The photon detectors $\mathbf{116_1}$, $\mathbf{116_2}$ may be implemented as photomultiplier tubes, silicon photomultipliers, avalanche photodiodes, PIN diodes, and the like, or any other suitable type of photodetector. In some embodiments, one photon detector can be used to implement both the photon detector $\mathbf{116_1}$ and the photon detector $\mathbf{116_2}$. In embodiments where two separate photon detectors $\mathbf{116_1}$, $\mathbf{116_2}$ are used, the first plurality of photons $\mathbf{308_1}$ is detected by the photon detector $\mathbf{116_1}$, and the second plurality of photons $\mathbf{308_2}$ is detected by the photon detector $\mathbf{116_2}$. In embodiments where one photon detector is used, the one photon detector is connected to both ends **122** and **124** of the scintillating fiber coil **112** and detects both the first and the second pluralities of photons $\mathbf{308_1}$, $\mathbf{308_2}$. In some embodiments, at least some of the scintillating fiber coil **112**, the fiber optic cables **114**$_1$ and **144**$_2$, and the photon detectors **116**$_1$ and **116**$_2$ are retained within a structure that substantially prevents stray photons from light sources, for example nearby lamps or the sun, from interfering with the photons **308**$_1$, **308**$_2$ travelling along the scintillating fiber coil **112**.

In some embodiments, the first end **122** of the scintillating fiber coil **112** is connected to the fiber optic cable **114**$_1$, and the second end **124** of the scintillating fiber coil **112** is connected to the fiber optic cable **114**$_2$. The fiber optic cables **114**$_1$, **114**$_2$ carry the pluralities of photons **308**$_1$, **308**$_2$ toward the photon detectors **116**$_1$, **116**$_2$. The fiber optic cables **114**$_1$ and **114**$_2$ are used to carry the pluralities of photons **308**$_1$, **308**$_2$ to the photon detectors **116**$_1$ and **116**$_2$ when the photon detectors **116**$_1$ and **116**$_2$ are located remotely from the portion **200**. Distancing the photon detectors **116**$_1$ and **116**$_2$ from the portion **200** may help to avoid contaminating signal interference by other emitted particles, for example by the radiotracer. In addition, in embodiments where the scanner **102** is a PET-MRI scanner, there are restrictions on the presence of magnetic materials in proximity to the scanner **102**. The fiber optic cables **114**$_1$, **114**$_2$ are used to convey the pluralities of photons **308**$_1$, **308**$_2$ away from the scanner **102**, for example to an adjacent or remote room where the photon detectors **116**$_1$, **116**$_2$ and/or other components of the scan system **100**. In other embodiments, the first and second ends **122**, **124** of the scintillating fiber coil **112** are connected to the photon detectors **116**$_1$, **116**$_2$ without the fiber optic cables **114**$_1$, **114**$_2$. In some such embodiments, the photon detectors **116**$_1$ and **116**$_2$ can be provided with shielding to avoid contamination by the other emitted particles.

Due to the material properties of the material which constitutes the scintillating fiber coil **112**, the photons of the pluralities of photons **308**$_1$, **308**$_2$ are subjected to an attenuation effect, which is manifested by the absorption of at least some of the photons of the pluralities of photons **308**$_1$, **308**$_2$ as the pluralities of photons **308**$_1$, **308**$_2$ travel along the scintillating fiber coil **112**. The rate at which the scintillating fiber coil **112** absorbs photons of the pluralities of photons **308**$_1$, **308**$_2$ is defined as an attenuation coefficient, and is typically expressed as a decibel (dB) reduction in signal intensity. The fiber optic cables **114**$_1$, **114**$_2$ also subject the pluralities of photons **308**$_1$, **308**$_2$ to attenuation. In some embodiments, the attenuation coefficient of the scintillating fiber coil **112** is higher than the attenuation coefficient of the fiber optic cables **114**$_1$, **114**$_2$. For example, the attenuation coefficient of the scintillating fiber coil **112** is one, two, three, or more orders of magnitude higher than the attenuation coefficient of the fiber optic cables **114**$_1$, **114**$_2$. In some other embodiments, the attenuation coefficient of the scintillating fiber coil **112** is less than that of the fiber optic cables **114**$_1$, **114**$_2$. It should be noted that the scintillating fiber coil **112** and the fiber optic cables **114**$_1$, **114**$_2$ can have any suitable attenuation coefficient. In some embodiments, the attenuation coefficient for the scintillating fiber coil **112** and/or the fiber optic cables **114**$_1$, **114**$_2$ is selected to optimize the transmission of the pluralities of photons **308**$_1$, **308**$_2$. In other embodiments, the attenuation coefficient for the scintillating fiber coil **112** and/or the fiber optic cables **114**$_1$, **114**$_2$ is selected to limit an intensity of the pluralities of photons **308**$_1$, **308**$_2$.

The photon detectors **116**$_1$, **116**$_2$ each receive a respective one of the pluralities of photons **308**$_1$, **308**$_2$ as attenuated first by the scintillating fiber coil **112**, and second by the respective fiber optic cables **114**$_1$, **114**$_2$. The photon detectors **116**$_1$, **116**$_2$ then transform the respective one of the pluralities of photons **308**$_1$, **308**$_2$ received into respective electrical signals. The photon detector **116**$_1$ transforms the first plurality of photons **308**$_1$ into a first electrical signal, and the photon detector **116**$_2$ transforms the second plurality of photons **308**$_2$ into a second electrical signal. The photon detectors **116**$_1$, **116**$_2$ can be any suitable type of photon detector, as described hereinabove.

The photon detectors **116**$_1$, **116**$_2$ are connected to the coincidence detector **117** which is configured for associating photons received at the photon detector **116**$_1$ with photons received at the photon detector **116**$_2$. More specifically, and with continued reference with FIG. **3**A, when the positron **304** interacts with the scintillating fiber coil **112**, the two pluralities of photons **308**$_1$ and **308**$_2$ are generated due to a common interaction event and sent along toward the photon detectors **116**$_1$, **116**$_2$. Similar behaviour occurs in the example of FIG. **3**B. The coincidence detector **117** detects when the two pluralities of photons **308**$_1$ and **308**$_2$ are received at the photon detectors **116**$_1$, **116**$_2$ and associates the two pluralities of photons **308**$_1$ and **308**$_2$ to one another.

In some embodiments, the coincidence detector **117** operates on the electrical signals produced by the photon detectors **116**$_1$, **116**$_2$. For example, the coincidence detector **117** is configured to determine an electrical signal produced by the photon detector **116**$_1$ is received at the same time as an electrical signal produced by the photon detector **116**$_2$. In other embodiments, for example where the photon detectors **116**$_1$ and **116**$_2$ are implemented by a single photon detector, the functionality of the coincidence detector **117** is also provided by the single photon detector, and can operate on the received pluralities of photons **308**$_1$ and **308**$_2$ and/or on the electrical signals produced thereby.

The electrical signals produced by the photon detectors **116**$_1$, **116**$_2$ are sent to the interaction position determination module **118**. In addition, information associating pluralities of photons **308**$_1$ and **308**$_2$ to one another produced by the coincidence detector **117** is sent to the interaction position determination module **118**. The electrical signal and the information from the coincidence detector **117** can be sent via one or more wires, via one or more wireless communication pathways, or via any other suitable communication medium. The photon detectors **116**$_1$, **116**$_2$ and the coincidence detector **117** are equipped with any suitable communication interfaces for providing the electrical signals to the interaction position determination module **118**.

The interaction position determination module **118** is configured for receiving the electrical signals produced by the photon detectors **116**$_1$, **116**$_2$ and the information produced by the coincidence detector **117**, and for determining a position along the scintillating fiber coil **112** at which the positron **304** interacted with the one of the molecules **306** of the scintillating fiber coil **112**, called a position of interaction, based on the electrical signals produced by the photon detectors **116**$_1$, **116**$_2$ and the associations between the pluralities of photons **308**$_1$ and **308**$_2$.

In some embodiments, the electrical signals provided to the interaction position determination module **118** are analog signals having respective amplitudes which are indicative of a photon count received by the photon detectors **116**$_1$, **116**$_2$. Put differently, the first electrical signal output by the photon detector **116**$_1$ has a first amplitude which is indicative of a number of photons present in the first plurality of photons **308**$_1$, and the second electrical signal output by the photon detector **116**$_2$ has a second amplitude which is indicative of a number of photons present in the second plurality of photons **308**$_2$. In some embodiments, the interaction position determination module **118** is configured to process the electrical signals received from the photon detectors **116**$_1$,

116_2. For example, the interaction position determination module **118** amplifies the electrical signals output by the photon detectors **116_1**, **116_2**, for example using one or more op-amps. In another example, the interaction position determination module **118** performs an analog-to-digital conversion of the electrical signals output by the photon detectors **116_1**, **116_2**.

Once the electrical signals received from the photon detectors **116_1**, **116_2** by the interaction position determination module **118** are processed, the interaction position determination module **118** associates the electrical signals with one another based on the information provided by the coincidence detector **117**. The interaction position determination module **118** then compares parameters of the pluralities of photons **308_1**, **308_2** to determine the position of interaction for the first and second pluralities of photons **308_1**, **308_2**.

In some embodiments, the interaction position determination module **118** determines the position of interaction based on relative degrees of attenuation of the first and second pluralities of photons **308_1**, **308_2**. If the plurality of photons **308_1** is less attenuated than the plurality of photons **308_2**, then the position of interaction is closer to the end **122** than to the end **124** of the scintillating fiber coil, and vice-versa. For example, the interaction position determination module **118** uses an algorithm to determine the position of interaction. In some embodiments, the interaction position determination module **118** uses the function R(z)

$$R(z)=2z/\lambda_a=\ln(S_2/S_1)$$

to determine the position of interaction, where z is the position of interaction, λ_a is the attenuation length of the scintillating fiber coil **112**, S_1 is the amplitude of the electrical signal generated by the photon detector **116_1**, and S_2 is the amplitude of the electrical signal generated by the photon detector **116_2**.

In other embodiments, the interaction position determination module **118** determines the position of interaction based on a comparison of wavelength spectra of the first and second pluralities of photons **308_1**, **308_2**. For example, the interaction position determination module **118** compares the wavelength spectra for the plurality of photons **308_1** in a given wavelength region to the wavelength spectra for the plurality of photons **308_2**.

The radiotracer activity monitor **110** determines the position of interactions between particles emitted by the individual radiotracer particles **302** and the scintillating fiber coil **112**. Additionally, the radiotracer activity monitor **110** is configured for performing determinations regarding positions of interactions for multiple particle-scintillating fiber coil interactions, and is further configured for using the multiple positions of interactions to determine an IF for the mathematical kinetic models implemented by the PET/SPECT/PET-MRI scan analyzer **104**. For example, the positions of interaction are used to determine the extent to which the radiotracer has traveled along the portion **200**, a rate at which the radiotracer has traveled along or through the portion **200**, or to determine a rate of emission of positrons by the radiotracer to establish a benchmark or standard of particle emission output by the radiotracer.

In some embodiments, the radiotracer activity monitor **110** uses the interactions within an initial time period of the radiotracer administration to determine a geometrical extent of the arteries **210** and veins **220** in the portion **200**, as described in greater detail hereinbelow. The initial time period may last for any suitable duration, for example short enough to rule out radiotracer migration outside the arteries **210** and veins **220**. In some embodiments, the measured geometrical extent of the arteries **210** and veins **220** is used throughout the remainder of a monitoring period during the PET/SPECT/PET-MRI scan, to rule out artificial ambient radiation, corresponding to radiotracer activity that originates from radiotracer particles outside the arteries **210** and veins **220**.

With reference to FIG. **4**, in some embodiments the radiotracer activity monitor **110** further includes an ambient radiation monitor **400**. The ambient radiation monitor **400** includes a pair of radiation detectors **412_1**, **412_2**, a pair of transmission cables **414_1**, **414_2**, a pair of readout modules **416_1**, **416_2**, and a coincidence detector **418**. The radiation detectors **412_1**, **412_2** are each connected to a respective one of the readout modules **416_1**, **416_2** by way of one of the transmission cables **414_1**, **414_2**. The radiation detectors **412_1**, **412_2** are configured to produce signals which are carried by the transmission cables **414_1**, **414_2** to the readout modules **416_1**, **416_2** and to the coincidence detector **418**. In some embodiments, the transmission cables **414_1**, **414_2** are omitted and the radiation detectors **412_1**, **412_2** are connected to the readout modules **416_1**, **416_2** and to the coincidence detector **418**.

In some embodiments, the ambient radiation monitor **400** is configured for determining a level of background radiation in the vicinity of the portion **200**. In some other embodiments, the ambient radiation monitor **400** is configured for determining a level of artificial ambient radiation produced by the presence of the radiotracer in other portions of the body beyond the portion **200** and/or the presence of the radiotracer in the portion **200** other than in the artery **210** and/or the vein **220**. In some embodiments, the ambient radiation monitor **400** is configured for determining both the level of background radiation and the level of artificial ambient radiation. The interaction position determination module **118** is provided with the level of background radiation and/or the level of artificial ambient radiation, which is used to further refine the determination of the positions of interaction. In some embodiments, the interaction position determination module **118** is configured to further refine the determination of the arterial IF based on the level of background radiation and/or the level of artificial ambient radiation.

In some embodiments, the radiation detectors **412_1** and **412_2** are connected to the readout modules **416_1** and **416_2** via respective transmission cables **414_1**, **414_2**. The radiation detectors **412_1** and **412_2** can be an ion chamber, scintillation detector, semiconductor detector, or any other suitable device for detecting radiation. The transmission cables **414_1** and **414_2** can be any suitable medium for transmitting information from the radiation detectors **412_1** and **412_2** to the photon detectors **416_1** and **416_2**, including electric wire to transmit electric signals, fiber optic cables to transmit pluralities of photons, or any other suitable transmission medium. The readout modules **416_1** and **416_2** can be op-amps, photon detectors, or any other suitable device for interpreting the readings obtained from the radiation detectors **412_1** and **412_2**. For example, in embodiments where the radiation detectors **412_1** and **412_2** are ion chambers, the transmission cables **414_1** and **414_2** are cables for transmitting electrical signals, and the readout modules **416_1** and **416_2** are amplifiers which amplify the analog electric signal produced by the ion chamber. The ambient radiation monitor **400** also includes a coincidence detector **418** to which the readout modules **416_1**, **416_2** are connected. The coincidence detector **418** is configured for operating in much the same way as the coincidence detector **117**, described hereinabove.

The radiation detectors **412**$_1$, **412**$_2$ are positioned proximate the portion **200** of the body, for example on opposite sides thereof, and are proximate the scintillating coil **112**. The radiation detectors **412**$_1$, **412**$_2$ are configured for monitoring the level of background radiation and/or the level of artificial ambient radiation in the vicinity of the portion **200**. For example, the detectors **412**$_1$ and **412**$_2$ can monitor stray radiation that is incident to the portion **200** from a different part of the body. The timing parameter that is associated with a background radiation event detected with the radiation detectors **412**$_1$ and **412**$_2$ can be compared with the timing parameters that are associated with the radiation detected with the scintillating fiber coil **112**. If the timing parameters match, then the signal detected with the scintillating coil **112** is rejected, as it originates from another part of the body than the portion **200**.

In some embodiments, the ambient radiation monitor **400** is configured for monitoring the radiotracer activity in the portion **200**. When a positron from the radiotracer interacts with an electron in the portion **200**, two photons which travel in opposite directions are produced. The ambient radiation monitor **400**, and more specifically the readout modules **416**$_1$ and **416**$_2$ and the coincidence detector **418** will be used to determine if the two photons originate from the same interaction event. The solid angle that the two radiation detectors **412**$_1$, **412**$_2$ span determines the subset of all photons from interaction events that can be detected. The solid angle, and the efficiency of the radiation detectors **412**$_1$, **412**$_2$, and the like, are used to determine the total radiotracer activity in the portion **200**. In some embodiments, the radiation detectors **412**$_1$ and **412**$_2$ are composed of a scintillating material, which may be similar to the material used in the scintillating fiber coil **112**. In some such embodiments, the radiation detectors **412**$_1$, **412**$_2$ and any associated light sensitive elements, for example the fiber optic cables **414**$_1$ and **414**$_2$ and the readout modules **416**$_1$ and **416**$_2$, are retained within a structure that substantially prevents stray photons from light sources, for example nearby lamps or the sun, from interfering with the photons **308**$_1$, **308**$_2$ travelling from the radiation detectors **412**$_1$ and **412**$_2$.

With reference to FIG. **5**, in some embodiments the radiotracer activity monitor **110** further includes one or more secondary scintillating fiber coils **512** to enhance or augment the precision of the determination of positions of interaction. The secondary scintillating fiber coil **512** is connected at first and second ends to secondary fiber optic cables **514**$_1$, **514**$_2$, which carry pluralities of photons generated within the secondary scintillating fiber coil to photon detectors **516**$_1$, **516**$_2$. In this embodiment, three cascaded coincidence detectors **518**$_1$-**518**$_3$ are included in the radiotracer activity monitor **110**. It should be noted that the embodiment of the radiotracer activity monitor **110** shown in FIG. **5** may be provided with or without the ambient radiation monitor **400**. The embodiment of FIG. **5** is used, for example, in situations of particularly high radiotracer activity in the portion **200**.

In some embodiments, the secondary scintillating fiber coil **512** is substantially identical to the scintillating fiber coil **112**, and is juxtaposed or adjacent thereto. For example, loops of the secondary scintillating fiber coil **512** can be concentric with the loops of the scintillating fiber coil **112**. In other embodiments, the secondary scintillating fiber coil **512** differs from the scintillating fiber coil in one or more ways, for example length, size, curved pattern spacing, curved pattern count, material, and the like. Additionally, in some other embodiments, the secondary scintillating fiber coil **512** is separated from the scintillating fiber coil **112** via an isolator, which can be a layer of opaque material, to prevent or minimize the risk of photons bleeding from one scintillating fiber coil to the other.

In the embodiment shown in FIG. **5**, the electrical signals output by the photon detectors **116**$_1$ and **516**$_1$ are fed to the first coincidence detector **518**$_1$, and the electrical signals output by the photon detectors **116**$_2$ and **516**$_2$ are fed to the second coincidence detector **518**$_2$. The coincidence detectors **518**$_1$ and **518**$_2$ output electrical signals which are sent to the third coincidence detector **518**$_3$, and the output of the third coincidence detector **518**$_3$ is sent to the interaction position determination module **118**.

The cascaded coincidence detectors **518**$_1$-**518**$_3$ are used to ensure that the pluralities of photons received at the photon detectors **116**$_1$, **116**$_2$, **516**$_1$ and **516**$_2$ originate from a common set of interaction events. The cascade coincidence detectors **518**$_1$-**518**$_3$ therefore reduce the risk of associating overlapping photon pluralities that originate from different interaction events with one and another.

It should also be noted that, although the embodiment of FIG. **5** shows two separate scintillating fiber coils, **112** and **512**, other embodiments of the radiotracer activity monitor **110** can include three, four, five, or more scintillating fiber coils, each with respective fiber optic cables and photon detectors. In addition, the cascaded coincidence detectors can be provided with additional levels to ensure that proper associations are made between received pluralities of photons.

In some embodiments, the length and/or loop count of the scintillating fiber coils **112**, **512** is adjustable to compensate for the number of interaction events detected. For example, when too many interaction events are detected by the photon detectors **116**$_1$, **116**$_2$ and/or **516**$_1$, **516**$_2$, the scintillating fiber coils **112**, **512** can be shortened and/or have loops removed therefrom. In the converse case, where too few interaction events are detected, the scintillating fiber coils **112**, **512** can be lengthened and/or have loops added thereto. For example, the scintillating fiber coil **112** and/or **512** is composed of a plurality of sections, each having one or more loops, and sections can be removed or added to adjust for the required level of activity in the scintillating fiber coil **112** and/or **512**.

In addition, in some embodiments a radiation shield or other protective device is placed over a section of the portion **200** to improve a positional resolution of the radiotracer activity monitor **110**. The radiation shield is configured for blocking any emissions by the radiotracer, such as positrons, from propagating. For example, if the positions of interaction cannot be determined with sufficient precision, the radiation shield can be placed on a top surface of the portion **200** between the portion **200** and the scintillating fiber coil **112**, thereby blocking any emitted particles from the top of the portion **200** from reaching the scintillating fiber coil. As a result, the scintillating fiber coil **112** receives positrons only from lateral surfaces of the portion **200**, which can lead to increased positional resolution.

With reference to FIG. **6**, there is shown a method **600** for determining a position of interaction along a scintillating fiber coil, for example the scintillating fiber coil **112**. The method **600** may be implemented by the radiotracer activity monitor **110**. At step **602**, optionally a level of artificial ambient radiation proximate a scintillating fiber coil, for example the scintillating fiber coil **112**, is measured. The artificial ambient radiation can include radiation produced by the radiotracer in other parts of the body (i.e. outside the portion **200**) and/or radiation produced by the radiotracer outside the artery **210** and/or the vein **220**. The level of artificial ambient radiation proximate a scintillating fiber coil can be determined by the ambient radiation monitor **400**, as described hereinabove.

At step **604**, the radiotracer activity monitor **110** detects a first plurality and a second plurality of photons, for example the pluralities of photons **308**$_1$, **308**$_2$, at first and second ends **122**, **124** of the scintillating fiber coil **112**. The radiotracer activity monitor **110** detects the pluralities of photons **308**$_1$, **308**$_2$ using, for example, the photon detectors **116**$_1$, **116**$_2$.

At step **606**, the radiotracer activity monitor **110** associates the first plurality of photons **308**$_1$ and the second plurality of photons **308**$_2$ with an interaction event based on a timing parameter. The interaction event, as described hereinabove, occurs when a radioactive particle, for example the positron **304** emitted by the radiotracer particle **302**, collides or otherwise interacts with the scintillating fiber **112**. For example, the association of the first plurality of photons **308**$_1$ and the second plurality of photons **308**$_2$ with the interaction event is performed by the interaction position determination module **118**.

At step **608**, a position of interaction for the interaction event is determined based on a comparison between first and second levels of attenuation to which the pluralities of photons **308**$_1$, **308**$_2$ were subjected. The position of interaction is a particular location along the scintillating fiber coil **112** where the positron interacted with one or more molecules **306** of the scintillating fiber coil **112**. For example, the interaction position determination module **118** uses an algorithm or equation to determine the position of interaction based on the first and second levels of attenuation. In some embodiments, the levels of attenuation are determined based on first and second amplitudes of electrical signals produced by the photon detectors **116**$_1$, **116**$_2$ which are connected to the scintillating fiber coil **112**.

Optionally, at step **610**, the position of interaction is adjusted based on the level of artificial ambient radiation determined at step **602**. In some embodiments, the adjustment includes adjusting the position value for the position of interaction, i.e. where along the scintillating fiber coil **112** the interaction occurred. In other embodiments, the adjustment includes discarding the position of interaction if the level of artificial ambient radiation indicates that the photons produced were a result of an interaction from a radiotracer particle outside the portion **200**, the artery **210**, and/or the vein **220**. It should be noted that step **610** can be performed based on the results of **602** and/or based on the results of **604**, **606** and **608**, For example, during a time period before the radiotracer is administered, the scintillating fiber coil **112** measures the background signal that is spontaneously generated in the system. This type of background is sometimes referred to as dark background. In another example, during initial seconds after the radiotracer has been administered, the scintillating fiber coil **112** can measure "well-defined" signals in the artery **210** and vein **220** before the radiotracers have migrated into smaller vessels adjacent to the artery **210** and vein **220**. In a further example, during a later portion of a monitoring period, the radiotracer activity monitor **110** uses the well-defined signals discussed in the preceding example (i.e., the signals that define the artery **210** and vein **220**) to reject radiation events that originate from radiotracers that have migrated into the smaller vessels. These events may be considered as the artificial ambient radiation and be rejected.

With reference to FIG. **7**, there is shown a method **700** for establishing a kinetic model IF in PET/SPECT/PET-MRI. In some embodiments, the method **700** is implemented at least in part by the radiotracer activity monitor **110**. Optionally, at step **702**, a level of background radiation proximate the portion **200**, and the scintillating fiber coil **112**, is measured. For example, the background radiation level is measured by the ambient radiation monitor **400**, or by the scintillating fiber coil **112**, or by any other suitable background radiation detection system. The level of background radiation is provided, for example, to the interaction position determination module **118**, or to any other suitable processing element of the radiotracer activity monitor **110**.

Optionally, at step **704**, a radiotracer is administered to a body, for example the body to which the portion **200** belongs. The radiotracer can be any suitable radiotracer having any suitable radioactive element, for example a positron-emitting radioisotope, which includes isotopes of any one or more of carbon, nitrogen, oxygen, fluorine, gallium, zirconium, rubidium, and the like, or a photon-emitting radioisotope, which includes technetium, indium, iodine, and the like. The radiotracer can be administered to the body in any suitable fashion, for example orally, intravenously, or in any other suitable fashion. In some embodiments, the radiotracer is administered directly to the artery **210**.

Optionally, at step **706**, one or more initial iterations of the method **600** are performed to determine positions for the artery **210** and/or the vein **220**. Shortly after the radiotracer is administered, the radiotracer is largely confined to the artery **210** and/or the vein **220**, for example until the heart or other circulatory system in the body has begun to circulate the radiotracer throughout the body. The method **600** can be performed one or more times and, with the radiotracer confined to the artery **210** and/or the vein **220**, the positions of the artery **210** and/or the vein **220** can be determined based on the positions of interactions detected by the method **600**. This can include optional steps **602** and **610**, which use the ambient radiation monitor **400** to measure artificial ambient radiation produced by the radiotracer or other radioactivity in other parts of the body and/or in the portion **200** that does not originate from the artery **210** and/or the vein **220**. In some embodiments, the ambient radiation monitor **400** measures a total amount of radioactivity produced within the portion **200**, and the radioactivity measured by the scintillating fiber coil **112** of the radiotracer activity monitor **110** is adjusted based on the measurements obtained from the ambient radiation monitor **400**.

At step **708**, the method **600** is performed to collect a position of interaction. The position of interaction can be stored in a memory or other data storage element of the radiotracer activity monitor **110** in any suitable fashion. Decision step **710** determines whether a sufficient number of positions of interaction have been collected by the radiotracer activity monitor **110**. If not, the method **700** returns to step **708**, and the method **600** is repeated to collect an additional position of interaction. If a sufficient number of positions of interaction have been collected, the method **700** proceeds to step **712**. The requirement for a sufficient number of positions of interaction may be a few dozen, a few hundred, a few thousand, or any other suitable number.

At step **712**, a kinetic model IF is established based on the positions of interaction. The kinetic model IF can be established in any suitable way, using any suitable algorithm or calculation. In embodiments where optional step **702** is performed, the level of background radiation is also used as part of the algorithm for establishing the kinetic model IF. Additionally, in embodiments of the method **700** where steps **702** and/or **706** are performed, establishing the kinetic model IF may include adjusting the positions of interaction and/or other elements of the kinetic model IF based on the level of background radiation and/or the arterial and/or veinal positions.

In embodiments where the radiotracer activity monitor **110** is the embodiment illustrated in FIG. **5**, therefore including the secondary scintillating coil **512** and the cascaded coincidence detectors $\mathbf{518}_1$-$\mathbf{518}_3$, the determination of the positions of interaction during the implementation of the method **600** at step **706** is performed based on the electrical signals received at both pairs of photon detectors $\mathbf{116}_1$, $\mathbf{116}_2$, and $\mathbf{516}_1$, $\mathbf{516}_2$. Thus, third and fourth pluralities of photons are received at the photon detectors $\mathbf{516}_1$, $\mathbf{516}_2$, in addition to the first and second pluralities of photons $\mathbf{308}_1$, $\mathbf{308}_2$ which are received by the photon detectors $\mathbf{116}_1$, $\mathbf{116}_2$, and the method **600** is performed for both the interaction events causing the first and second pluralities of photons $\mathbf{308}_1$, $\mathbf{308}_2$ and the interaction events causing the pluralities of photons received by the photon detectors $\mathbf{516}_1$, $\mathbf{516}_2$, and the kinetic model IF is based on both sets of positions of interaction.

With reference to FIG. **8**, the methods **600** and/or **700** may be implemented by a computing device **810**, comprising a processing unit **812** and a memory **814** which has stored therein computer-executable instructions **816**. The processing unit **812** may comprise any suitable devices configured to implement the method **200** such that instructions **816**, when executed by the computing device **810** or other programmable apparatus, may cause the functions/acts/steps of the method **200** described herein to be executed. The processing unit **812** may comprise, for example, any type of general-purpose microprocessor or microcontroller, a digital signal processing (DSP) processor, a central processing unit (CPU), an integrated circuit, a field programmable gate array (FPGA), a reconfigurable processor, other suitably programmed or programmable logic circuits, or any combination thereof.

The memory **814** may comprise any suitable known or other machine-readable storage medium. The memory **814** may comprise non-transitory computer readable storage medium, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. The memory **814** may include a suitable combination of any type of computer memory that is located either internally or externally to device, for example random-access memory (RAM), read-only memory (ROM), compact disc read-only memory (CDROM), electro-optical memory, magneto-optical memory, erasable programmable read-only memory (EPROM), and electrically-erasable programmable read-only memory (EEPROM), Ferroelectric RAM (FRAM) or the like. Memory **814** may comprise any storage means (e.g., devices) suitable for retrievably storing machine-readable instructions **816** executable by processing unit **812**.

In some embodiments, a single computing device, such as the computing device **810**, can be used to implement any one or more of the scan analyzer **104**, the radiotracer activity monitor **110**, and the interaction position determination module **118**. In other embodiments, separate computing devices, for example the computing device **810**, are provided for each of the scan analyzer **104**, the radiotracer activity monitor **110**, and the interaction position determination module **118**.

The methods and systems for determining a position of interaction along a scintillating fiber coil and for establishing a kinetic model IF in PET/SPECT/PET-MRI described herein may be implemented in a high level procedural or object oriented programming or scripting language, or a combination thereof, to communicate with or assist in the operation of a computer system, for example the computing device **810**. Alternatively, the methods and systems for determining a position of interaction along a scintillating fiber coil and for establishing a kinetic model IF in PET/SPECT/PET-MRI may be implemented in assembly or machine language. The language may be a compiled or interpreted language. Program code for implementing the methods and systems for controlling operation of the deprime valve may be stored on a storage media or a device, for example a ROM, a magnetic disk, an optical disc, a flash drive, or any other suitable storage media or device. The program code may be readable by a general or special-purpose programmable computer for configuring and operating the computer when the storage media or device is read by the computer to perform the procedures described herein. Embodiments of the methods and systems for determining a position of interaction along a scintillating fiber coil and for establishing a kinetic model IF in PET/SPECT/PET-MRI may also be considered to be implemented by way of a non-transitory computer-readable storage medium having a computer program stored thereon. The computer program may comprise computer-readable instructions which cause a computer, or more specifically the processing unit **812** of the computing device **810**, to operate in a specific and predefined manner to perform the functions described herein.

Computer-executable instructions may be in many forms, including program modules, executed by one or more computers or other devices. Generally, program modules include routines, programs, objects, components, data structures, etc., that perform particular tasks or implement particular abstract data types. Typically the functionality of the program modules may be combined or distributed as desired in various embodiments.

The above description is meant to be exemplary only, and one skilled in the relevant arts will recognize that changes may be made to the embodiments described without departing from the scope of the invention disclosed. For example, the blocks and/or operations in the flowcharts and drawings described herein are for purposes of example only. There may be many variations to these blocks and/or operations without departing from the teachings of the present disclosure. For instance, the blocks may be performed in a differing order, or blocks may be added, deleted, or modified. While illustrated in the block diagrams as groups of discrete components communicating with each other via distinct data signal connections, it will be understood by those skilled in the art that the present embodiments are provided by a combination of hardware and software components, with some components being implemented by a given function or operation of a hardware or software system, and many of the data paths illustrated being implemented by data communication within a computer application or operating system. The structure illustrated is thus provided for efficiency of teaching the present embodiment. The present disclosure may be embodied in other specific forms without departing from the subject matter of the claims. Also, one skilled in the relevant arts will appreciate that while the systems, methods and computer readable mediums disclosed and shown herein may comprise a specific number of elements/components, the systems, methods and computer readable mediums may be modified to include additional or fewer of such elements/components. The present disclosure is also intended to cover and embrace all suitable changes in technology. Modifications which fall within the scope of the present invention will be apparent to those skilled in the art, in light of a review of this disclosure, and such modifications are intended to fall within the appended claims.

The invention claimed is:

1. A method for determining a position of interaction along a scintillating fiber coil, comprising:

positioning the scintillating fiber coil to substantially cover a portion of a body;

detecting a first plurality and second plurality of photons at first and second ends of the scintillating fiber coil, respectively, the first and second pluralities of photons produced by an interaction event between a radiotracer and the scintillating fiber coil;

associating the first plurality of photons and the second plurality of photons with the interaction event based on a timing parameter; and

determining a position of interaction for the interaction event based on a comparison between a first parameter of the first plurality of photons and a second parameter of the second plurality of photons.

2. The method of claim **1**, further comprising measuring a level of background radiation proximate the scintillating fiber coil, wherein determining a position of interaction comprises adjusting the first and second levels of attenuation based on the level of background radiation.

3. The method of claim **1**, wherein detecting the first plurality and second plurality of photons produced by the scintillating fiber coil comprises receiving the first and second pluralities of photons via an optical fiber.

4. The method of claim **3**, wherein an attenuation coefficient of the optical fiber is lower than an attenuation coefficient of the scintillating fiber coil.

5. The method of claim **1**, wherein detecting the first plurality and second plurality of photons produced by the scintillating fiber coil comprises determining, via a coincidence detector, that the first plurality of photons and the second plurality of photons are produced by the interaction event based on a time of receipt of the first plurality of photons and of the second plurality of photons.

6. The method of claim **1**, wherein the first and second parameters are first and second attenuation levels, respectively.

7. The method of claim **1**, wherein the portion of the body is a wrist.

8. The method of claim **1**, further comprising administering the radiotracer.

9. A method for establishing a kinetic model input function in one of positron emission tomography and single-photon emission computed tomography, comprising:

determining a plurality of positions of interaction along a scintillating fiber coil, the scintillating fiber coil arranged for substantially covering a portion of a body, by:

detecting a first plurality and second plurality of photons at first and second ends of the scintillating fiber coil, respectively, the first and second pluralities of photons produced by an interaction event between a radiotracer and the scintillating fiber coil;

associating the first plurality of photons and the second plurality of photons with the interaction event based on a timing parameter; and

determining a position of interaction for the interaction event based on a comparison between a first parameter of the first plurality of photons and a second parameter of the second plurality of photons; and

establishing the kinetic model input function based on the plurality of positions of interaction.

10. A device for establishing a kinetic model input function in positron emission tomography and single-photon emission computed tomography, comprising:

a scintillating fiber coil arranged for substantially covering a portion of a body, the scintillating fiber coil having a first end and a second end;

at least one photon detector optically connected to the first and second ends of the scintillating fiber coil; and

a processing device communicatively coupled to the at least one photon detector and configured for:

for each of a plurality of interaction events between the scintillating fiber coil and a radiotracer in the body:

detecting first and second pluralities of photons at first and second ends of the scintillating fiber coil, respectively, the first and second pluralities of photons produced by the interaction event;

associating the first plurality of photons and the second plurality of photons with the interaction event based on a timing parameter; and

determining a position of interaction for the interaction event based on a comparison between a first parameter of the first plurality of photons and a second parameter of the second plurality of photons; and

establishing the kinetic model input function based on the positions of interaction.

11. The device of claim **10**, further comprising an ambient radiation monitor communicatively coupled to the processing device, wherein the processing device is further configured for obtaining a measurement of a level of background radiation proximate the scintillating fiber coil from the ambient radiation monitor, and wherein determining a position of interaction comprises adjusting the first and second levels of attenuation based on the level of background radiation.

12. The device of claim **10**, wherein the level of background radiation comprises radiation produced by the body.

13. The device of claim **10**, further comprising an optical fiber, wherein the at least one photon detector is optically connected to the first and second ends of the scintillating fiber coil via the optical fiber.

14. The device of claim **13**, wherein an attenuation coefficient of the optical fiber is lower than an attenuation coefficient of the scintillating fiber coil.

15. The device of claim **10**, further comprising a coincidence detector, wherein the processing device is configured for operating the coincidence detector to detect the first plurality and second plurality of photons produced by the scintillating fiber coil to determine that first plurality of photons and the second plurality of photons are produced by the interaction event based on a time of receipt of the first plurality of photons and of the second plurality of photons.

16. The device of claim **10**, wherein the first and second parameters are first and second attenuation levels, respectively.

17. The device of claim **10**, wherein the portion of the body is a wrist.

18. The device of claim **10**, further comprising a subsequent scintillating fiber coil optically connected to the at least one photon detector, wherein the processing device is further configured for performing the steps of detecting, associating, and determining for third and fourth pluralities of photons for a subsequent plurality of interaction events between the subsequent scintillating fiber coil and the radiotracer.

19. The device of claim **18**, wherein the subsequent scintillating fiber coil is arranged for substantially covering a subsequent portion of the body at least in part different from the portion of the body.

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